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(54) Title: LOW WATER PEAK OPTICAL WAVEGUIDE AND METHOD OF MANUFACTURING SAME

(57) Abstract: A cylindrical glass body having a low water content core and nearclad region and method of manufacturing such a cylindrical glass body for use in the manufacture of optical waveguide fiber is disclosed. Preferably the glass body is made using an outside vapor deposition process, wherein a core cane is first formed, preferably using outside vapor deposition methods. The core cane is then treated with deuterium gas prior to having additional core and/or cladding material applied to the core cane. Using such techniques, optical fiber preforms can be achieved having core and nearclad region which have a water content sufficiently low such that an optical waveguide fiber made from the cylindrical glass body of the present invention exhibits an optical attenuation of less than about 0.35 dB/km, and preferably less than about 0.31 dB/km at a measured wavelength of 1380nm.

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**LOW WATER PEAK OPTICAL WAVEGUIDE AND METHOD OF  
MANUFACTURING SAME**

**BACKGROUND OF THE INVENTION**

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1. Field of the Invention

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The present invention relates generally to the field of optical waveguide fibers, and more particularly to optical waveguide fiber preforms and methods of making optical waveguide fiber preforms from which low water peak optical waveguide fibers are formed.

2. Technical Background

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Generally speaking, a significant goal of the telecommunications industry is to transmit greater amounts of information, over longer distances, in shorter periods of time. Typically, as the number of systems users and frequency of system use increase, demand for system resources increases as well. One way of meeting this demand is by increasing the bandwidth of the medium used to carry this information over long distances. In optical telecommunications systems, the demand for optical waveguide fibers having increased bandwidth is particularly high.

In recent years, significant advancements have been made in the manufacture of optical waveguide fiber, which in turn have increased the

usable light carrying capacity of the fiber. However, as is well known, electromagnetic radiation traveling through an optical waveguide fiber is subject to attenuation or loss due to several mechanisms. Although some of these mechanisms can not be reduced, others have been eliminated, or at least substantially reduced. A particularly problematic component of optical fiber attenuation is the attenuation due to absorption by the optical waveguide fiber of impurities present in the light guiding region of the fiber. Particularly troublesome is the attenuation caused by the hydroxyl radical (OH), which can be formed in the optical waveguide fiber when a source of hydrogen is present in the fiber material, or when hydrogen available from several sources during the fiber manufacturing process diffuses into the glass. Generally speaking, the hydrogen bonds with the oxygen available in the SiO<sub>2</sub> and/or GeO<sub>2</sub> and/or other oxygen containing compound in the glass matrix to form the OH and/or H<sub>2</sub>O bonds referred to generally as "water". The attenuation increase due to OH or water in the glass can be as high as about 0.5 to 1.0 dB/km or higher, with the attenuation peak generally occupying the 1380nm window. As used herein, the phrase, "1380nm window" is defined as the range of wavelengths between about 1330nm to about 1470nm. The attenuation peak, which occurs at 1383 nm, generally referred to as the water peak, has prevented usable electromagnetic transmission in the 1380nm window.

Until recently, telecommunications systems avoided the water peak residing in the 1380nm window by operating in the 1310nm window and/or the 1550nm window, among others. With the advent of wavelength division multiplexing ("WDM") and advancements in amplifier technology, which enable telecommunications systems to operate over broad wavelength ranges, it is possible that all wavelengths between about 1300nm and about 1650nm may be used for data transfer in optical telecommunications systems. Removing the water peak from optical waveguide fiber used with such systems is an important aspect of enabling system operation over this entire range.

### SUMMARY OF THE INVENTION

One aspect of the present invention relates to a method of fabricating a cylindrical glass body for use in manufacturing optical waveguide fiber. The method includes the steps of chemically reacting at least some of the constituents of a moving fluid mixture that includes at least one glass forming precursor compound in an oxidizing medium to form a silica-based reaction product. The silica-based reaction product is consolidated into a silica-based glass precursor body for use in manufacturing optical waveguide fiber. The silica-based glass body includes at least a portion of what will become the core region of the optical fiber preform. Preferably, the silica-based glass precursor body is a core cane, which preferably is formed by OVD deposition techniques. Prior to having additional core and/or cladding material formed on the precursor body, the consolidated glass precursor body is exposed to deuterium gas. Additional core and/or cladding material is then applied, preferably via OVD techniques, onto the precursor body to form an optical fiber preform.

The glass precursor body is preferably exposed to a mixture of deuterium in a gas selected from the group consisting of helium, argon, neon, nitrogen or other inert gases or mixtures thereof. Preferably, the deuterium exposing step is carried out for a time and at a temperature sufficient to prevent OH formation in the glass precursor body prior to or during formation of the remainder of the optical fiber preform, especially when OVD techniques are used to deposit the remainder of the cladding. The deuterium treatment step is also preferably carried out for a time and at a temperature that is sufficient so that, when said precursor body is used to form an optical fiber preform, and an optical fiber is drawn therefrom, the attenuation of said optical fiber at 1380 is less than about .4 dB/km, more preferably less than about .33, and most preferably less than about .31 dB/km. For example, at 2% deuterium in helium the exposing step preferably takes place above about 600°C, more preferably above about 800°C, most preferably above about 1000°C, for at least 1 hour, more preferably at least 2 hours, although higher temperatures and higher deuterium concentrations may enable successful treatment in lesser time periods.

In a preferred embodiment for making single mode fiber, the core region is formed and drawn into a consolidated glass core cane. Core cane, as used herein, means a consolidated glass precursor body which must receive additional core and/or cladding material to produce a complete optical fiber preform. Most preferably, the consolidated glass core cane includes the entire physical core region. The core cane may optionally include a small portion of what will become the overall cladding of the optical fiber preform (also called a near-clad region of the core cane). The small near-clad region of the core cane is preferably large enough so that, when the resultant optical fiber is drawn into a fiber, the optical core (i.e. the region in the fiber that transmits power) includes both the core and a portion of the nearclad region of the core cane. In other words, while the core would transmit the bulk of transmitted power, the near clad region would also transmit some smaller amount of power, and outside the nearclad region, no significant power would be transmitted. To achieve this result, the ratio of the physical core (e.g., in the case of standard germania doped single mode fiber, the germania doped region) to the diameter of the near clad region (i.e., the outer diameter of the core cane), i.e., the so-called core/clad ratio of the core cane, is greater than about .15, more preferably greater than about .25, and most greater than about .30. Having a thicker near clad region on the consolidated glass core cane prior to deuterium treatment and subsequent formation of the remainder of the cladding on the core cane, helps assure that no water will be present in the light transmitting region of the resultant optical fiber. After deuterium treatment of the glass precursor body, additional soot is applied using a plurality of outside vapor deposition burners, thus increasing the productivity of optical fiber preform manufacture.

In a preferred embodiment, a core cane is formed by depositing doped glass soot onto a mandrel, and removing the mandrel to form a soot body having a hole therein. The soot body may be exposed to additional dopants if desired. Then, prior to and/or during consolidation, the soot body is dried using a drying agent such as chlorine gas. After the core cane has been formed into a soot body, dried and consolidated to form a core cane, the resultant dried

consolidated glass core cane body is treated using deuterium gas in accordance with the present invention. Subsequent to the deuterium treatment, the glass precursor body is overcladded as described above.

5 Preferably, the overcladding of the glass precursor body is accomplished via an outside vapor deposition process. Such overcladding of glass precursor core canes via outside vapor deposition previously would have resulted in the formation of OH within the light carrying region of the core cane, and this OH formation would detrimentally effect the light carrying properties of the optical fiber by creating increased attenuation in the 1380 window. However, by  
10 following the process steps of the present invention, and treating the consolidated glass with deuterium, applicants have discovered that the remainder of the optical fiber preform can be formed using OVD deposition of silica, without forming detrimental OH within the light curing region of the core cane. The glass precursor body is most preferably formed entirely via outside  
15 vapor deposition. Prior to being consolidated, the soot precursor body is dried via exposure to a drying gas, such as chlorine. Preferably, the precursor body is dried and consolidated in the same furnace structure without removing the precursor body from the furnace structure between the drying and consolidating steps. Subsequent to being chemically dried and consolidated, additional  
20 cladding soot is deposited via a plurality of OVD burners disposed along the length of said precursor body.

Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the  
25 invention as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the invention, and are intended to provide an overview or framework for understanding the nature and  
30 character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings

illustrate various embodiments of the invention, and together with the description serve to explain the principles and operation of the invention.

### BRIEF DESCRIPTION OF THE DRAWINGS

5           FIG. 1 is a perspective view of a cylindrical glass body shown depicting an optical fiber preform made of a core cane and overcladding in accordance with the present invention;

          FIG. 2 schematically illustrates the manufacture of a porous body using an outside vapor deposition process in accordance with the present invention;

10           FIG. 3 is a cross-sectional view of the porous body of FIG. 2 shown suspended within a consolidation furnace;

          FIG. 4 is a cross-sectional view of a sintered glass preform resulting from consolidation of the porous body depicted in FIG. 4 shown being drawn into a reduced diameter core cane.

15           FIG. 5 is a core cane being hung in a furnace to receive a deuterium treatment in accordance with the invention.

          FIG. 6 illustrates a schematic of an optical fiber having more complex refractive index profile made in accordance with the present invention.

### 20           DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

          Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Whenever possible, the same reference numerals will be used throughout the drawings to refer to the same or like parts. An  
25           exemplary embodiment of optical fiber preform (or an optical fiber drawn from an optical fiber preform) in accordance with the present invention is shown in FIG. 1, and is designated generally throughout by reference numeral 20. In accordance with the invention, optical fiber preform 20 includes a core region 22, clad or near clad region 24, and over clad region 26. Core region 22 may  
30           include index of refraction varying dopants such as germanium, fluorine, and other known dopants which may be used to raise or lower the index of refraction of the core region 22. The near clad region 24 and over clad region

26 are typically made of pure silica, although dopants could be employed in this region as well, as long as the relative refractive index of the overall clad regions 24 and 26 is lower than that of core region 22, so that the resultant optical fiber will guide light. Core region 22 is the physical core region of the optical fiber, meaning that it is the region in which the majority of light is guided along the fiber. Such a region can be formed by employing index of refraction increasing dopants within the core region 22, or index of refraction decreasing dopants outside the core region 22. The physical core region is delimited by the presence or absence of these index of refraction increasing dopants that cause the majority of light to be guided in the core.

In a preferred embodiment of the present invention, a consolidated glass core cane is first made which consists at least of core region 22 and preferably also includes near clad region 24. Such core canes could be manufactured using a variety of methods known in the art, including, but not limited to, outside vapor deposition (OVD), vapor axial deposition (VAD), inside process (IV), or modified chemical vapor deposition (MCVD), or plasma vapor deposition (PCVD).

The consolidated glass core cane is then treated with deuterium in accordance with the invention, after which a consolidated glass overclad region 24 is formed on the core cane to form a complete optical fiber preform.

In a preferred embodiment, optical fiber preform 20 is formed by chemically reacting at least some of the constituents of a moving fluid mixture including at least one glass-forming precursor compound in an oxidizing medium to form a silica-based reaction product. At least a portion of this reaction product is directed toward a substrate, to form a porous body, at least a portion of which includes hydrogen bonded to oxygen. The porous body may be formed, for example, by depositing layers of soot onto a mandrel or bait rod via an OVD process. Such an OVD process is illustrated in FIG. 2. As shown in FIG. 2, a bait rod or mandrel 30 is inserted through a tubular handle 32 and mounted on a lathe (not shown). The lathe is designed to rotate mandrel 30 in close proximity with a soot-generating burner 34. As mandrel 30 is rotated and reciprocated back and forth with respect to the burner 34, silica-based reaction



product 36, known generally as soot, is directed toward mandrel 30. At least a portion of silica-based reaction product 36 is deposited on mandrel 30 and on a portion of handle 32 to form a porous body 38 thereon. While this aspect of the present invention has been described in conjunction with a mandrel 30 that is traversed by a lathe, it will be understood by those skilled in the art that soot generating burner 34 can traverse rather than mandrel 30. Moreover, this aspect of the present invention is not intended to limit soot deposition to an OVD process. Rather, other methods of chemically reacting at least some of the constituents of a moving fluid mixture, such as, but not limited to, liquid delivery of at least one glass-forming precursor compound in an oxidizing medium can be used to form the silica-based reaction product of the present invention, as disclosed, for example, in U.S. Provisional Patent Application Serial No. 60/095,736, filed on August 7, 1997, and PCT Application Serial No. PCT/US98/25608, filed on December 3, 1998, the contents of which are hereby incorporated by reference. Moreover, other processes, such as the inside vapor (IV) deposition process, and modified chemical vapor deposition (MCVD) process are also applicable to the present invention.

Once the desired quantity of soot has been deposited on mandrel 30 to form core region 22 and near-clad region 24 in Fig. 1, soot deposition is terminated and mandrel 30 is removed from porous body 38. In accordance with the present invention and as depicted in FIG. 3, upon removal of mandrel 30, porous body 38 defines a centerline hole 40 passing axially therethrough. In a preferred embodiment of the invention, an OVD process is employed to make an initial soot precursor body consisting of core region 22 and near clad region 24. The resultant soot precursor body 28 is then dried and consolidated into a consolidated glass precursor body. Core region 22 is the physical core which includes an index of refraction which is higher than that of cladding regions 24 and 26. For example, the core region 22 may consist of various combinations of germanium and fluorine dopant levels. While the raised index of refraction in the core region 22 causes the majority of light to propagate in the physical core region 22, small amounts of light will also propagate in the region adjacent core region 22, namely near-clad region 24 (and, if near-clad

region 24 is thin enough, also in over-clad region 26). Consequently, it is important that OH species be removed from both core region 22 and any portion of near-clad region 24 or overclad region 26 that will propagate any significant amount of the light intensity along the length of optical fiber.

5                   Consequently, in a preferred embodiment, both the core region 22 and all of the near clad region 24 that will transmit any of the light along the optical fiber, is formed in a first OVD process as illustrated in FIG. 1. The resultant soot precursor body 28 is then dried and consolidated into a consolidated glass precursor body.

10                   As illustrated in Fig. 3, to effect drying and consolidation of the soot precursor body 38, porous body 38 is suspended by handle 32 on a downfeed handle 42 and positioned within a consolidation furnace 44. The end of centerline hole 40 remote from handle 32 may be fitted with a bottom plug 46 prior to positioning porous body 38 within consolidation furnace 44. Porous  
15                   body 38 is preferably chemically dried, for example, by exposing porous body 38 to a chlorine containing atmosphere at elevated temperature within consolidation furnace 44. Chlorine containing atmosphere 50 effectively removes water and other impurities from porous body 38, which otherwise would have an undesirable effect on the properties of optical waveguide fiber  
20                   manufactured from porous body 38. In an OVD formed porous body 38, the chlorine flows sufficiently through the soot to effectively dry the entire blank, including the region surrounding centerline hole 40. Following the chemical drying step, the temperature of the furnace is elevated to a temperature sufficient to consolidate the soot blank into a sintered glass preform, typically  
25                   about 1500° C. In accordance with the method of the present invention, centerline hole 40 is closed, either during or following the consolidation step, under conditions suitable to result in a solid sintered glass body that can be further processed to form an optical waveguide fiber exhibiting optical  
30                   attenuation of less than about 0.35 dB/km, and preferably less than about 0.31 dB/km at a wavelength of 1380nm. In the preferred embodiment, centerline region 24 has a weighted average OH content of less than about 1 ppb.

In the past, following chemical drying and consolidation, the glass preform was routinely exposed to a water containing environment, such as ambient atmosphere, for example, when the glass preform was removed from the consolidation furnace and moved to a redraw furnace for further processing steps. Invariably, optical waveguide fibers manufactured using such preforms exhibited excessively high levels of optical attenuation in the 1380 nm window. It has since been found that this high attenuation, known generally as the "water peak", is largely due to absorption of water by that portion of the glass preform surrounding the centerline hole prior to centerline hole closure. While not wishing to be bound by theory, it is believed that physisorbed water ( $H_2O$ ) in the glass bounding the centerline hole results substantially instantaneously when the glass is exposed to an atmosphere containing a hydrogen compound such as, but not limited to water ( $H_2O$ ). Moreover, the greater the exposure time, the greater the amount of water absorbed by the glass. Thus, any exposure to ambient atmosphere, or any atmosphere containing a hydrogen compound, no matter how short the period of time, will rewet that portion of the glass preform bounding the centerline hole. Such rewetting provides the impurities that cause the water peak exhibited by optical waveguide fibers manufactured using standard fiber manufacture processing techniques from blanks formed by an OVD process.

In accordance with the preferred method of the present invention, closure of the core cane centerline hole is performed under the drying conditions such as those discussed herein which are suitable to result in a solid glass body that can be used to manufacture an optical waveguide fiber that exhibits optical attenuation of less than about 0.31 dB/km at a wavelength of 1380nm can be facilitated in a number of ways. In a first preferred embodiment of the method of the present invention, exposure of the centerline hole to an atmosphere containing a hydrogen compound is prevented following the steps of chemically drying and consolidating the porous body. In accordance with this embodiment, the centerline hole does not have an opportunity to be rewet prior to centerline hole closure. In a second preferred embodiment of the method of the present invention, water contained within the portion of the

sintered glass preform surrounding the centerline hole as a result of rewetting following consolidation is chemically removed from the glass prior to centerline hole closure, preferably at redraw.

5 In accordance with the first preferred embodiment of the method of the present invention, rewetting of the glass bounding the centerline hole can be significantly reduced by closing the centerline hole during consolidation. As illustrated in FIG. 3, the end of centerline hole 40 remote from handle 32 is fitted with a glass plug 46 prior to the consolidation step. This may be achieved, for example, by lowering porous body 38 subsequent to or during  
10 drying a hot zone (not shown) of consolidation furnace 44. The elevated temperature, preferably about 1500° C, in the hot zone sinters porous body 38 as it enters the hot zone. The inwardly directed sintering forces reduce the diameter of porous body 38 thereby closing porous body 38 onto plug 46 to effectively seal one end of centerline hole 40. Porous body 38 is further down  
15 driven into the hotter zone of the furnace to sinter the remainder of porous body 38 thereby forming a sintered glass preform having a centerline hole 40 sealed at its plugged ends. Closing of the hole 40 may be facilitated by exposing centerline hole 40 to a vacuum, for example, an absolute pressure of no more than 10 Torr, more preferably no more than 100 mTorr, through an inner handle  
20 52, which communicates with centerline hole 40 through handle 32.

At redraw, the sintered glass preforms formed as described above are suspended within a furnace 68 by downfeed handles 42 as illustrated in FIG. 4. The temperature within furnace 68 is elevated to a temperature which is sufficient to stretch the glass preforms, preferably about 1950°C to about  
25 2100°C, and thereby reduce the diameters of the preforms to form a cylindrical glass body such as a rod or core cane. As depicted in FIG. 4, sintered glass preform 70, corresponding to porous body 38 depicted in FIG. 3 and having a closed centerline region 72, is heated, preferably in an inert gas atmosphere such as He, and stretched to form a reduced diameter 74 having a centerline  
30 region 76 extending axially therethrough. Alternatively, rather than suspending the core

Previously, after core cane was formed, additional over clad soot 26 was applied to the core cane 76 via outside vapor deposition techniques, without any pretreatment to the core cane 76. Without wishing to be bound by theory, applicants now believe that OH groups somehow become incorporated into the glass core cane 76, perhaps by components of the flame reacting with the glass. This is a particular problem when the additional soot is being deposited onto the core cane 76 via an OVD method. Consequently, in accordance with the present invention, prior to additional over-clad soot 26 being added to core cane 76, the core cane 76 is suspended within furnace 68, as illustrated in Fig. 5, and treated with deuterium for a time and temperature which is sufficient to prevent rewetting of the consolidated glass core cane 76. In a preferred embodiment, the core cane 76 is treated in an atmosphere preferably containing greater than 2% and less than 50% by volume, and more preferably greater than 4% and less than 15% deuterium gas by volume, the remainder of the gas being made up of helium or argon. Preferably, during the deuterium treatment step, the furnace is held at a temperature of at least 600°C, more preferably greater than 800°C, and most preferably 1000°C or higher. We have found that by exposing core canes 76 to such deuterium pretreatment prior to the deposition of additional cladding material 26, rewetting of the core and near clad regions 24 of the core cane can be precluded entirely, resulting in an optical fiber having an attenuation at 1383 which is less than .33 dB/km, more preferably less than .31 dB/km.

After the core cane 76 has been treated with deuterium gas, additional core clad 26 may be deposited onto core cane 76 to complete the optical fiber preform. Such additional cladding material 26 may be deposited, for example, using the process described above with respect to FIG. 2, only this time instead of the soot 36 being deposited onto mandrel 30 the soot 36 would be deposited onto core cane 76 which has been previously treated with deuterium gas. Also, the additional over-clad region 26 is preferably deposited via a plurality of OVD soot deposition burners positioned along the length of core cane 76.

It also should be recognized that the invention is not limited to the treatment of core canes 76 which are comprised of an entire core region and a

near-clad region. To illustrate, references made to FIG. 6 which illustrates an optical fiber 20 having a core refractive index profile 80 (shown schematically across the width of the preform) which is more complex than standard single mode fiber. Such optical fibers could be made using a variety of methods. For example, in a preferred embodiment, such profiles are made using an OVD process in which central core region 82, which is comprised of germania doped silica, is first made using the process described above with respect to FIG. 2-4, to thereby form a core cane having a refractive index profile as illustrated in core segment 82. This first core cane region 82 is then deuterium treated in accordance with the invention. The second, and adjacent core region 84 can then be formed by forming a soot body 28 as illustrated in FIG. 2, removing this soot body 28 from mandrel 30, and then doping this soot body using fluorine prior to consolidation. The consolidated core cane 82 could then be inserted into the fluorine doped soot body 84 and the resultant structure consolidated to form a second core cane body consisting of the central core segment 82 and second core segment 84. This second core cane also preferably receives the deuterium pretreatment step, before having additional soot deposited via an OVD process, as illustrated in FIG. 2, to form the remainder of the core refractive index profile 80, and a near clad region outside of the annular germania doped region, thereby forming third core segment 86. The additional soot could then be consolidated into glass, redrawn into a third core cane, consisting of regions 82, 84, and 86 which is treated with deuterium in accordance with the present invention before receiving over clad material 78 which completes the optical fiber preform. The resulting solid sintered glass preform can then be removed from consolidation furnace 44 and stored for further processing at a later time, or moved to a redraw furnace where it can be drawn into a reduced diameter cane. In either event, since centerline hole 40 is closed (i.e., the sintered glass preform has a solid centerline region), the centerline region will not be exposed to ambient atmosphere and thus will not be rewet upon removal from consolidation furnace 44.

EXAMPLES

The invention will be further clarified by the following examples, which are intended to be exemplary of the invention. For each example set forth below, it will be understood that distances are described as being measured from the top of the furnace muffle.

Example 1

This example illustrates the effect of the deuterium treatment of the present invention on conventional single mode fiber. A one meter soot blank having a core/clad ratio of .41 and, a step index germania doped core (index of refraction  $\Delta = .37$ , where  $\Delta = \frac{r_{core} - r_{clad}}{r_{clad}}$ ) was formed by an OVD process and then loaded into the top portion of a consolidation furnace maintained at a temperature of approximately 1000° C – 1200° C to a depth of approximately 1090 mm. The blank was initially pre-purged for approximately 15 minutes with a 20 SLPM He flow rate in the muffle and 1.5 SLPM He flow rate along the centerline hole. Purging was followed by a 240 minute drying step. During the drying step a flow rate of approximately 0.825 SLPM Cl<sub>2</sub> and 20 SLPM He was passed through the muffle. The blank was then downfed from 1090 mm to a depth of approximately 2730 mm into the hot zone of the furnace at a rate of about 5 mm/min. under a He flow rate of 20 SLPM within the muffle. At a depth of approximately 2510 mm, a 300 SCCM flow of Cl<sub>2</sub> was delivered through the centerline hole of the blank until the blank reached a depth of approximately 2540 mm, at which time the centerline flow of Cl<sub>2</sub> was terminated. At that depth, and upon termination of the centerline flow, a vacuum pump communicating with the centerline was activated to reduce the pressure within the centerline hole. Vacuum continued to be drawn until the bottom of the blank reached a depth of 2730 mm and the top portion of the blank closed on the top plug, thereby sealing the centerline hole. The sealed sintered preform was then drawn into a solid cane having a diameter of about

12.1 mm in a redraw furnace. Prior to overcladding, the core canes were subjected to various deuterium pretreatments, as illustrated in Table 1 below.

TABLE 1

Time	Temp	%D2 in He	% 1380 Peak loss
None	-	none	0
30 mins	1000C	2	0
60 mins	1000C	2	20
120 mins	1000C	2	50
240mins	1000C	5	100%

The cane was then overclad with additional silica soot using OVD techniques, consolidated into a optical fiber preform, and drawn into optical fiber. The resultant peak loss at 1380 compared to untreated core cane is illustrated in Table 1.

It will be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the invention. For example, various combinations of glass rod into soot tube, or glass rod into glass tube (i.e., so-called rod in tube techniques) manufacturing techniques could be employed to achieve various types of optical fiber having varying complexity to their refractive index profile. In many of these processes, deuterium treatment to the glass precursor body could be employed to prevent rewetting of the consolidated glass bodies, particularly prior to additional soot deposition. It is intended that the present invention cover these and other modifications and variations of this invention that come within the scope of the appended claims and their equivalents.



What is claimed is:

- 5        1.        A method of fabricating a glass body for use in manufacturing optical waveguide fiber, comprising the steps of:
- forming a consolidated glass precursor body for use in manufacturing an optical fiber preform, said precursor body comprising at least a partial core region of said preform;
- 10        exposing said glass precursor body to deuterium gas; and
- forming additional cladding on said precursor body to form an optical fiber preform.
- 15        2.        The method of claim 1, wherein said consolidated glass precursor body is made using a soot deposition step, and said method further comprises, prior to said deuterium exposing step, exposing said soot to a drying gas capable of substantially removing OH content from said soot and consolidating said soot into said glass precursor body.
- 20        3.        The method of claim 2, wherein said glass precursor body comprises a complete core region of said preform.
- 25        4.        The method of claim 3, wherein said glass precursor body comprises at least a portion of the glass cladding region of said preform.
5.        The method of claim 1, wherein said forming additional cladding comprises depositing cladding soot on said precursor body and consolidating said soot to form said optical fiber preform.
- 30        6.        The method of claim 2, wherein said forming step comprises forming said soot on said precursor body via an outside vapor deposition process.

7. The method of claim 3 wherein the gas in said exposing step comprises deuterium mixed with a gas selected from the group consisting of helium, argon, nitrogen, and mixtures thereof.

5 8. The method of claim 3, wherein the exposing step is carried out at a temperature of at least 600°C.

9. The method of claim 3, wherein the exposing step is carried out for a time of at least 1 hour.

10 10. The method of claim 6 wherein the gas comprises less than 50 volume percent deuterium gas.

11. The method of claim 3, wherein the glass precursor body comprises a core region surrounded by a partial clad region.

12. The method of claim 8, wherein the ratio of the clad diameter to the core diameter is greater than about .15.

13. The method of claim 8 wherein the ratio of the clad diameter to the core diameter is greater than about .25.

14. The method of claim 8, wherein the ratio of the clad diameter to the core diameter is greater than about .30.

15. The method of claim 2, wherein said depositing additional soot step comprises depositing said soot via an outside vapor deposition process, and said exposing step is carried out for a time and at a temperature that is sufficient so that, when said precursor body is used to form an optical fiber preform, and an optical fiber is drawn therefrom, the attenuation of said optical fiber at 1380 is less than about .35 dB/km.

16. The method of claim 1, further comprising, prior to said forming cladding on said precursor body, forming additional core material on said precursor body.

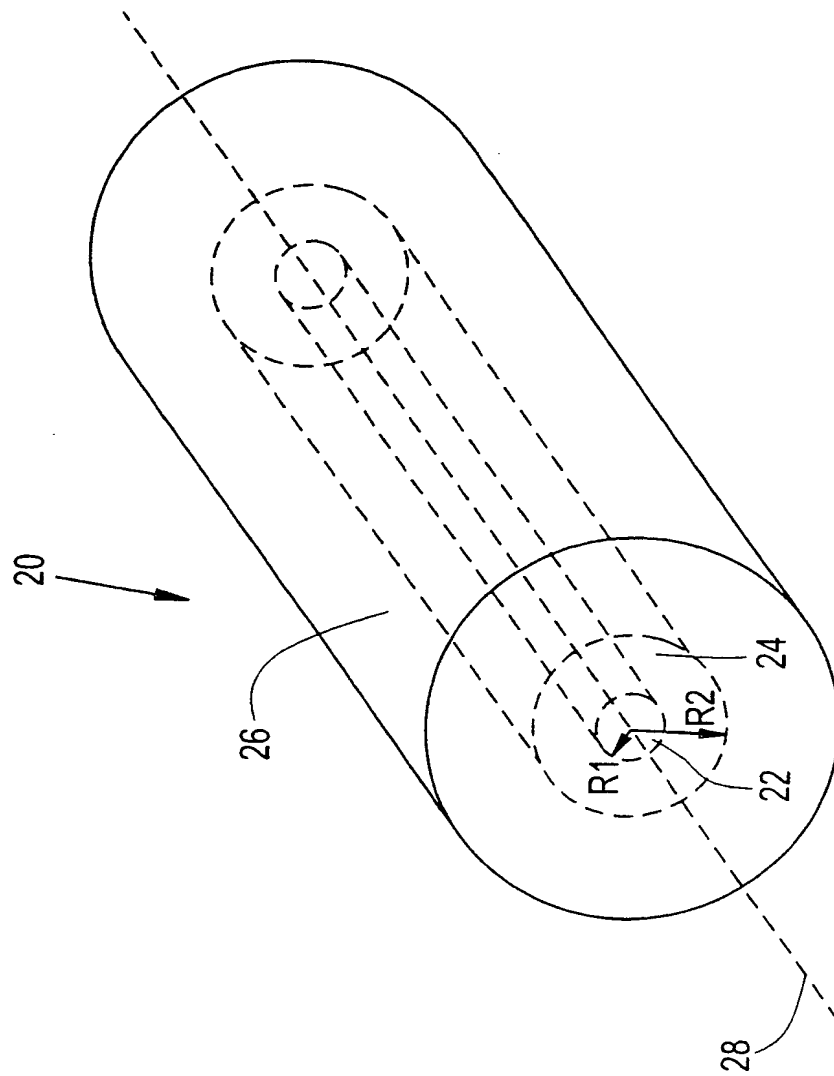
5 17. The method of claim 1 wherein said forming additional core material comprises inserting said precursor body into a tube and consolidated the rod and tube into a second precursor body.

10 18. The method of claim 1, wherein said forming additional core material comprises depositing additional core soot on said precursor body in a vapor deposition process, and consolidating said soot to form a second consolidated glass precursor body.

15 19. The method of claim 1, wherein said deuterium in said exposing step comprises less than 50 percent by volume deuterium.

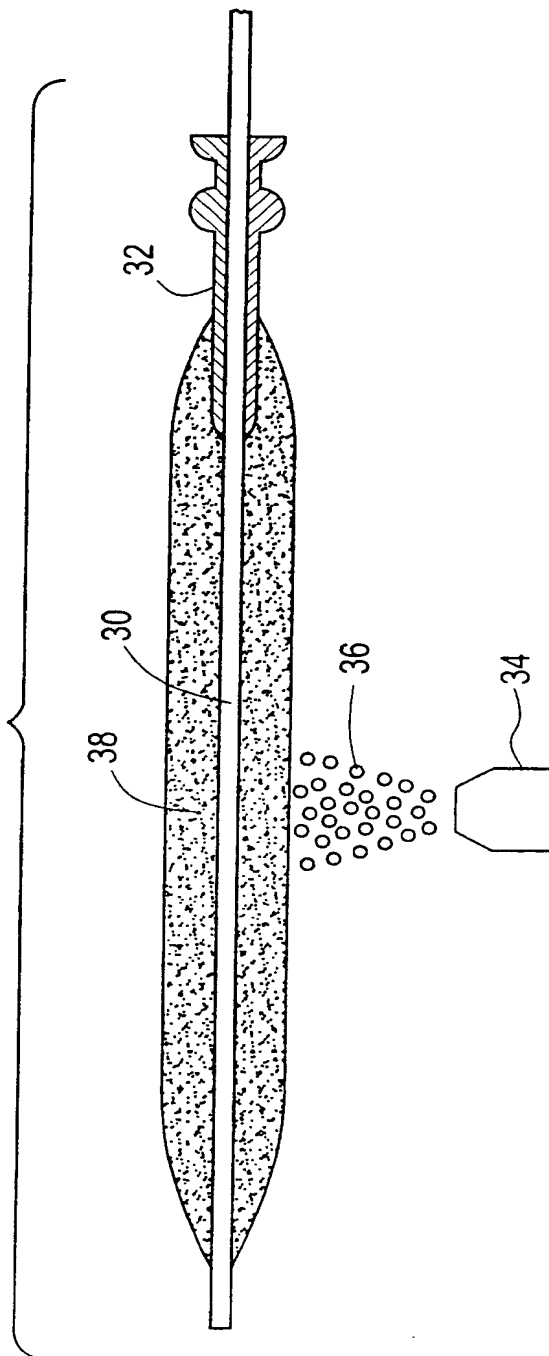
20. The method of claim 1, wherein said exposing step comprises exposing said glass precursor body to a deuterium gas burner flame.

FIG. 1



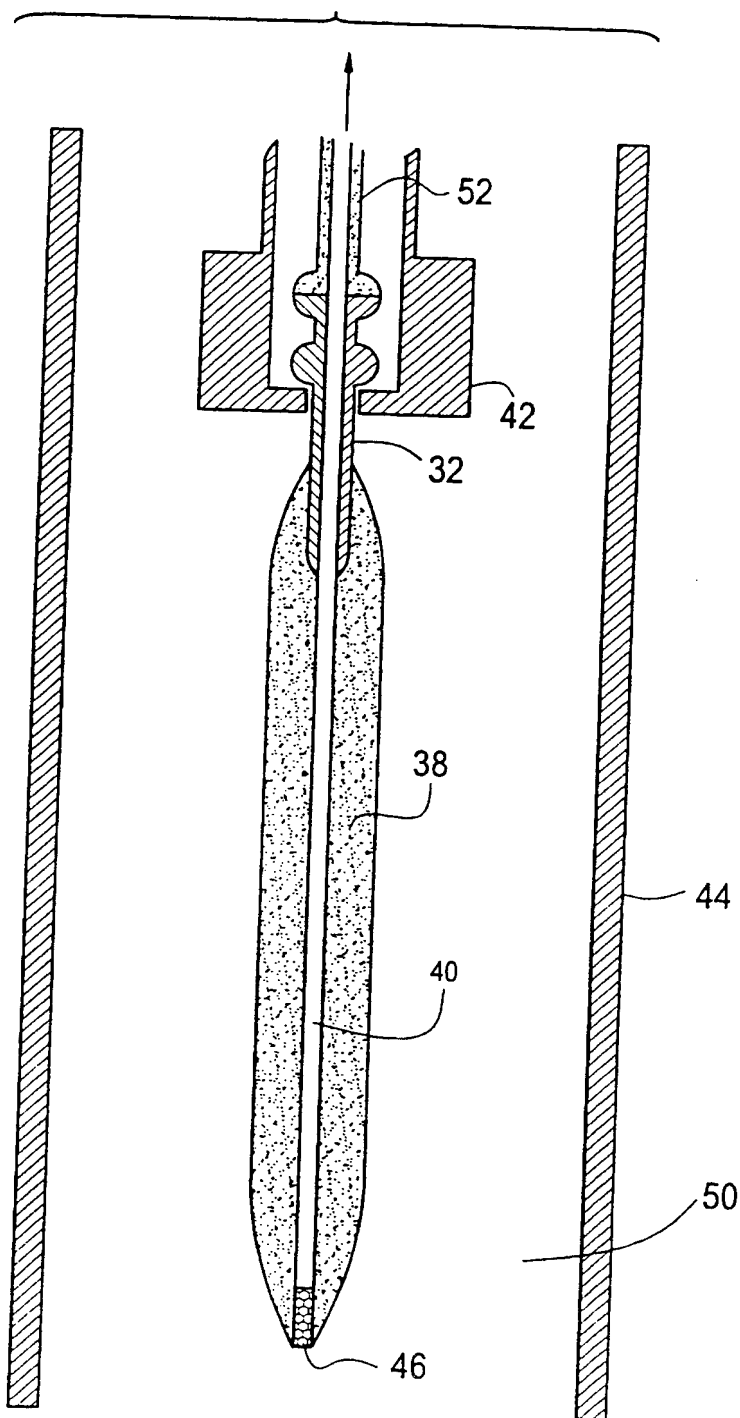
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FIG. 2



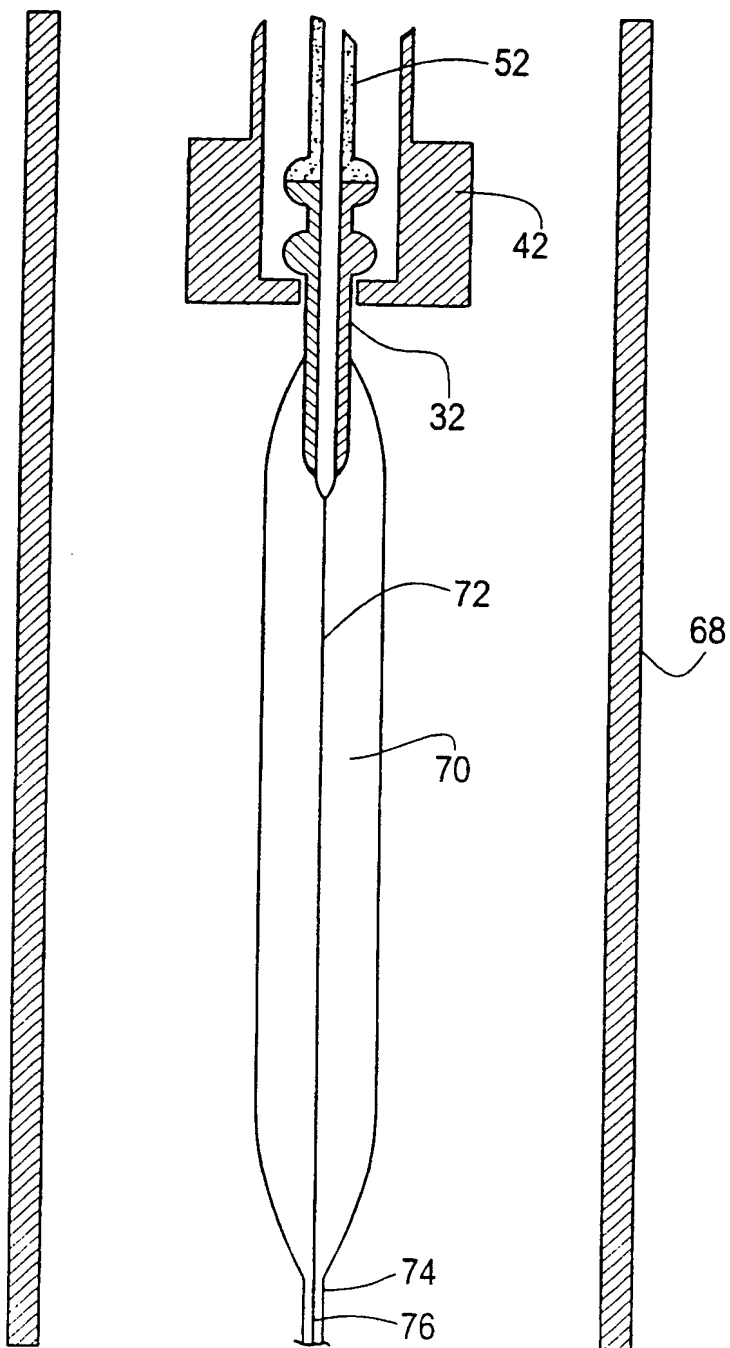
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FIG. 3



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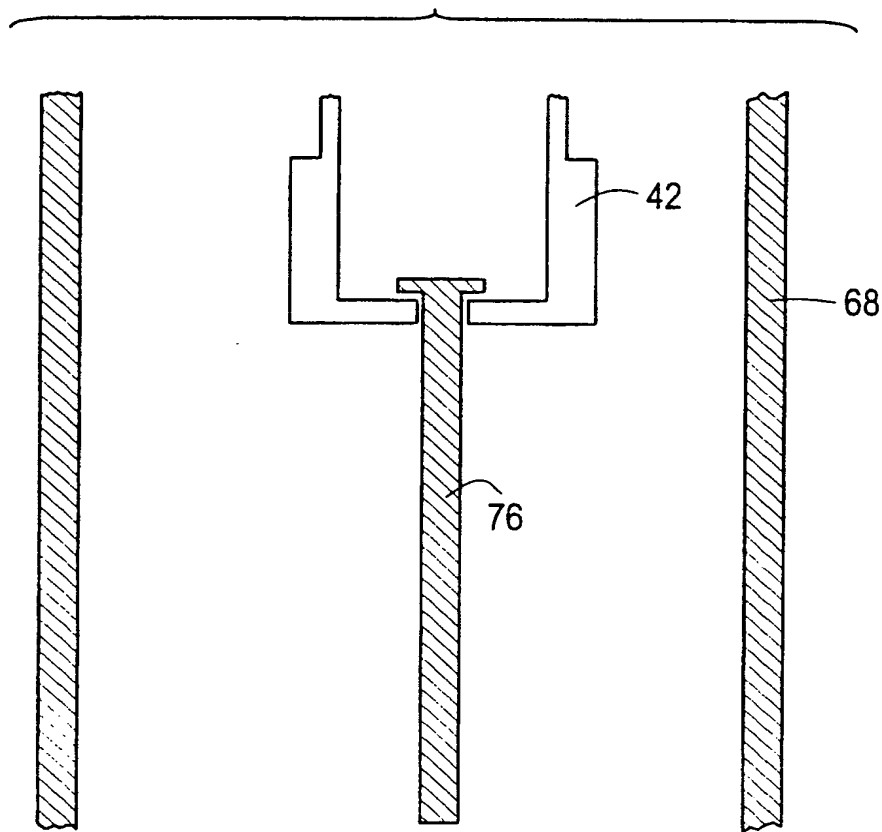
FIG. 4



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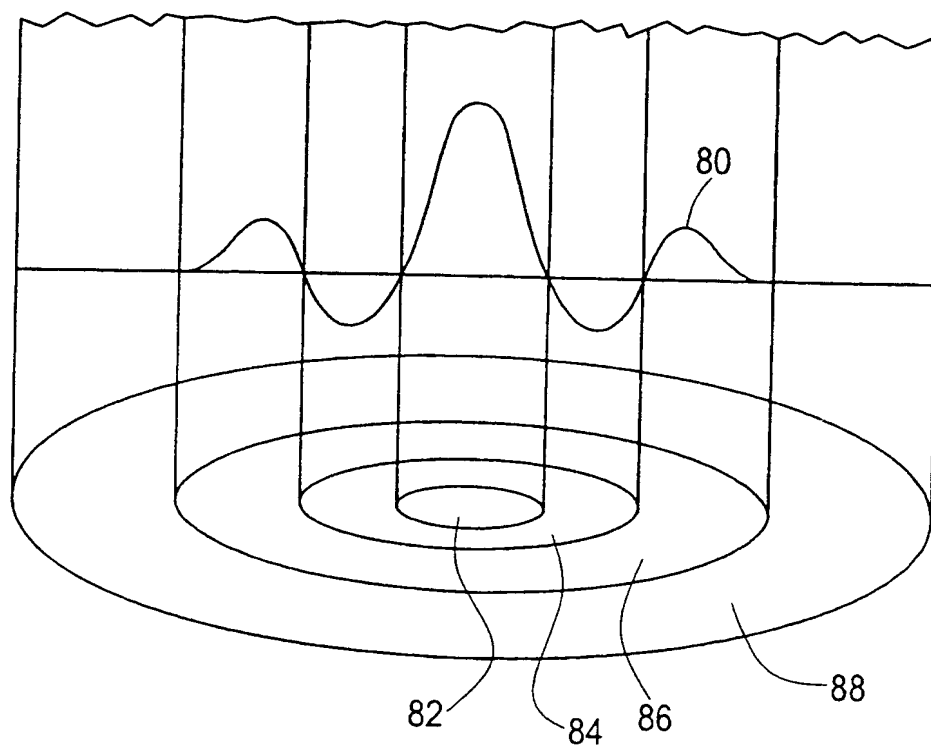
FIG. 5





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FIG. 6



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US00/30496

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :C03B 37/018, 32/00

US CL :65/424, 426, 421, 379, 382

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 65/424, 426, 421, 379, 382

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
WEST

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,515,612 A (BURRUS, Jr. et al) 07 May 1985, col. 5, lines 2-6 and col. 6, lines 40-50.	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

12 JANUARY 2001

Date of mailing of the international search report

09 FEB 2001

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